

## **Explanation of Tasks**

### ***Phase 2A – Connection Fatigue Testing***

#### *Laboratory Specimen Fixture and Design*

Marquette University researchers will meet with University of Wisconsin at Milwaukee researchers to discuss equipment and apparatus' available for the fatigue testing and will develop plans and details for specimens and fixturing. The Marquette University research team will also meet with WisDOT/WHRP oversight committee members in Madison to finalize connection specimen configurations. Retrofit measures will also be discussed and one retrofit measure worthy of implementing in the fatigue testing program will be identified.

#### *Laboratory Fixture and Specimen Fabrication*

Local steel fabricators with connections to Marquette University and the University of Wisconsin at Milwaukee will be consulted and it is expected that test fixtures needed to conduct the fatigue testing research will be in-kind donations of time and materials from these local fabricators. Both MU and UWM have had long-standing and positive interaction with local steel fabricators over decades. It is expected that there will be no problems receiving these in-kind donations.

Steel material and fabrication needed to make specimens for the planned fatigue testing are expected to be in-kind donations from several sources: corporations that provide mast-arm structures to WisDOT (*e.g.* Ameron, Millerbernd, Valmont); and/or local fabricators. The PI (Foley) is a member of the American Institute of Steel Construction's Committee on Research and Specification Task Committee 6 (Connections). His contacts within AISC-Research and the HSS fabricators makes these in-kind donations of fabrication, time and materials likely. The WisDOT/WHRP oversight committee will also be consulted to determine if any new mast-arm sign and signal support structures are being fabricated for installation within the state. If so, the manufacturers providing these structures will be approached for in-kind donation of additional pieces for fatigue testing conducted through this project.

#### *Specimen Instrumentation and Fatigue Testing*

The instrumentation and fatigue testing will be conducted at the University of Wisconsin at Milwaukee Structural Testing Laboratory. The fatigue testing will be conducted under the direct supervision of Dr. Jian Zhao (Assistant Professor of Civil Engineering and Mechanics at UWM). Dr. Zhao, his graduate research assistant, UWM's laboratory personnel and the MU research team will work closely with one another to carry out the fatigue testing program.

#### *Fatigue Testing Data Synthesis*

Upon completion of the fatigue testing program, the UWM and MU research team will collaboratively synthesize the fatigue testing data and weave it into the database of previous fatigue tests that were identified in Phase 1 of the research effort. Synthesis of both un-treated (non-retrofitted) specimens and the retrofit specimens will be completed.

#### *Fatigue Testing Reporting*

The fatigue testing program will include a short, white-paper type research report that describes the fixturing and testing protocols implemented as well as the results obtained. It is expected that this white-paper report will be used by the MU research team to draft the final report for the research effort.

### ***Phase 2B – In-Situ Field Testing, Finite Element Modeling and Data Acquisition***

#### *Field Monitoring Site Reconnaissance*

Phase 1 of the research effort made recommendations with regard to cities within Wisconsin where field monitoring will most likely yield fruitful and useful results. These cities were Appleton, Green Bay and Milwaukee. The MU research team will investigate these cities and identify candidate structures within each

for in-situ testing and long-term monitoring. Tentative criteria that will be used in final site selection are: (a) correlation with city and structure with meaningful wind speed and direction; (b) availability of resources for wireless data transmission (e.g. proximity to facility with broad-band network access); (c) ability to safely conduct free vibration testing with minimal traffic disruption. Strong consideration for ease of repair to the data acquisition system during the long-term monitoring period will also be given.

#### Data Acquisition System Development

Budget provisions have been made for purchase and installation of a stand-alone data acquisition (DAQ) system for the field monitoring program. This system will be purchased and tested prior to the long-term monitoring and the short-term free vibration testing. The MU researchers will also investigate the possibility of using DAQ systems purchased by WisDOT through the "Deck Truss Monitoring Program" research effort recently completed. It should be noted that the DAQ system will include measurement of strain, strain-ranges via rainflow counting, wind speed, and wind direction.

#### Finite Element Modeling for Field Correlation

The MU research team will carry out detailed FE simulations prior to the in-situ free-vibration testing and long-term monitoring. FE models will be calibrated using the free vibration testing data obtained from the in-situ tests (e.g. determining reasonable inherent damping levels for the FEA). The FE modeling methodologies developed will be used to help extrapolate field testing results and fatigue induced fracture risk evaluation to general locations within the state.

#### Installation of DAQ System and Testing

The MU research team will install the DAQ system at the field site and thoroughly test it for operational reliability and stability. The DAQ system will be set up for wireless transmission of data from the field to an MU-based server for storage.

#### In-Situ Field Free-Vibration Testing

The MU research team will conduct free vibration testing of the monitored structure. These free vibration tests will be used to determine appropriate levels of inherent and aerodynamic damping within typical mast-arm signal and sign support structures. The free-vibration tests will facilitate much more accurate finite element modeling.

#### Field Testing Synthesis and Reporting

The MU research team will synthesize the in-situ free-vibration tests and make recommendations with regard to inherent and aerodynamic damping levels that are present in typical mast-arm signal and sign support structures. The free-vibration test data will be synthesized into a short white-paper report making recommendations with regard to damping in these structural systems and recommendations with regard to FE modeling approaches for these structural systems.

#### Field Data Acquisition Period

The MU research team will set up and begin an automated field data acquisition period using the DAQ system. This longer-term data acquisition period will extend into phase 3 of the research effort, but it is envisioned that at least 6 months of contiguous data will be obtained.

## Fatigue Risks in the Connections of Sign Support Structures – Phases 2

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**Phase 2A – Connection Fatigue Testing:** *January 2009 through December 2009*  
*Marquette University*  
*University of Wisconsin at Milwaukee*

Task	J-09	F-09	M-09	A-09	M-09	J-09	J-09	A-09	S-09	O-09	N-09	D-09
Laboratory Specimen and Fixture Design												
Laboratory Fixture and Specimen Fabrication												
Specimen Instrumentation and Fatigue Testing												
Fatigue Testing Data Synthesis												
Fatigue Testing Reporting												

**Personnel:**

Marquette University:

Christopher M. Foley, PhD, PE (Principal Investigator)

Baolin Wan, PhD (Co-Principal Investigator)

PhD Graduate Research Assistant (to be named)

University of Wisconsin at Milwaukee:

Jian Zhao, PhD (Principal Investigator for Fatigue Testing Sub-Contract)

Graduate Research Assistant (to be named)

**Phase 2B – In-Situ Field Testing, Finite Element Modeling and Data Acquisition:** *January 2009 through December 2009*  
*Marquette University*

Task	J-09	F-09	M-09	A-09	M-09	J-09	J-09	A-09	S-09	O-09	N-09	D-09
Field Monitoring Site Reconnaissance												
Data Acquisition System Development												
Finite Element Modeling for Field Correlation												
Installation of DAQ System and Testing												
In-Situ Field Free-Vibration Testing												
Field Testing Synthesis and Reporting												
Field Data Acquisition Period												

**Personnel:**

Marquette University:

Christopher M. Foley, PhD, PE (Principal Investigator)

Baolin Wan, PhD (Co-Principal Investigator)

PhD Graduate Research Assistant (to be named)